

SMOG—Who Does It Hurt?

What You Need to Know About Ozone and Your Health

On a hot, smoggy summer day, have you ever wondered: Is the air safe to breathe? Should I be concerned about going outside? In fact, breathing smoggy air can be hazardous because smog contains ozone, a pollutant that can harm our health when there are elevated levels in the air we breathe. This booklet will tell you what kinds of health effects ozone can cause, when you should be concerned, and what you can do to avoid dangerous exposures.



Ozone, a harmful air pollutant, is a major ingredient of smog.

What is ozone?

- In the Earth's lower atmosphere, near ground level, ozone is created when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources react chemically in the presence of sunlight.
- In the Earth's upper atmosphere (known as the stratosphere), ozone occurs naturally and helps to protect human health by shielding us from the sun's harmful ultraviolet rays.

This text focuses on ground-level ozone, which is a harmful air pollutant.

Should I be concerned about ozone exposure?

That depends on who you are and how much ozone is in the air. Most people only have to worry about ozone exposure when concentrations reach high or very high levels. In most U.S. communities, this only happens a few times a year—mostly in the summer. (In some heavily populated areas, it can happen more frequently.) In general, as ozone concentrations increase, more and more people experience health effects, the effects become more serious, and more people are admitted to the hospital for respiratory problems. When ozone levels are very high, *everyone* should be concerned about ozone exposure.

Scientists have found that about one out of every three people in the United States is at a higher risk of experiencing [ozone-related health effects](#). If you are a member of a "sensitive group," you should pay special attention to ozone levels in your area. This booklet describes several tools that the U.S. Environmental Protection Agency (EPA), in partnership with state and local agencies, has developed to inform the public about local ozone levels. These tools provide the information you need to decide whether ozone levels on any particular day may be harmful to you. When ozone concentrations reach unhealthy levels, you can take simple precautions (described below) to protect your health.

Who is most at risk from ozone?

Four groups of people, described below, are particularly sensitive to ozone. These groups become sensitive to ozone when they are active outdoors because physical activity (such as jogging or outdoor work) causes people to breathe faster and more deeply. During activity, ozone penetrates deeper into the parts of the lungs that are more vulnerable to injury. Sensitive groups include:

- **Children.** Active children are the group at highest risk from ozone exposure. Such children often spend a large part of their summer vacation outdoors, engaged in vigorous activities either in their neighborhood or at summer camp. Children are also more likely to have asthma or other respiratory illnesses. Asthma is the most common chronic disease for children and may be aggravated by ozone exposure.
- **Adults who are active outdoors.** Healthy adults who exercise or work outdoors are considered a "sensitive group" because they have a higher level of exposure to ozone than people who are less active outdoors.
- **People with respiratory diseases, such as asthma.** There is no evidence that ozone causes asthma or other chronic respiratory disease, but these diseases do make the lungs more vulnerable to the effects of ozone. Thus, individuals with these conditions will generally experience the effects of ozone earlier and at lower levels than less sensitive individuals.
- **People with unusual susceptibility to ozone.** Scientists don't yet know why, but some healthy people are simply more sensitive to ozone than others. These individuals may experience more health effects from ozone exposure than the average person.

Scientists have studied other groups to find out whether they are at increased risk from ozone. So far there is no evidence to suggest that either the elderly or people with heart disease have heightened sensitivity to ozone. However, like other adults, elderly people will be at higher risk from ozone exposure if they suffer from respiratory disease, are active outdoors, or are unusually susceptible to ozone as described above.



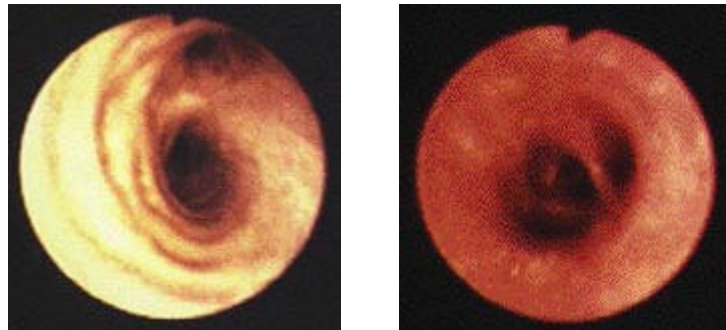
Active children are the group at highest risk from ozone exposure.
Adults of all ages who are active outdoors are also at risk.

How might ozone affect my health?

Scientists have been studying the effects of ozone on human health for many years. So far, they have found that ozone can cause several types of short-term health effects in the lungs:

- **Ozone can irritate the respiratory system.** When this happens, you might start coughing, feel an irritation in your throat, and/or experience an uncomfortable sensation in your chest. These symptoms can last for a few hours after ozone exposure and may even become painful.
- **Ozone can reduce lung function.** When scientists refer to "lung function," they mean the volume of air that you draw in when you take a full breath and the speed at which you are able to blow out the air. Ozone can make it more difficult for you to breathe as deeply and vigorously as you normally would. When this happens, you may notice that breathing starts to feel uncomfortable. If you are exercising or working outdoors, you may notice that you are taking more rapid and shallow breaths than normal. Reduced lung function can be a particular problem for outdoor workers, competitive athletes, and people who are exercising outdoors on days when ozone concentrations are high.
- **Ozone can aggravate asthma.** When ozone levels are high, more asthmatics have asthma attacks that require a doctor's attention or the use of additional asthma medication. One reason this happens is that ozone makes people with asthma more sensitive to allergens, which are the most common triggers for asthma attacks. (Allergens are substances that cause allergies and come from such things as dust mites, cockroaches, pets, fungus, and pollen). Also, asthmatics are more affected by the reduced lung function and irritation that ozone causes in the respiratory system.

- **Ozone can inflame and temporarily damage the lining of the lung.** Some scientists have compared ozone's effect on the lining of the lung to the effect of sunburn on the skin. Ozone damages the cells that line the air spaces in the lung. Within a few days, the damaged cells are replaced and the old cells are shed—much in the way that skin peels after a sunburn. If this kind of damage occurs repeatedly, the lung may change permanently in a way that could cause long-term health effects and a reduced quality of life.
- **Scientists suspect that ozone may have other effects on people's health.** Ozone may aggravate chronic lung diseases, such as emphysema and bronchitis. Also, studies in animals suggest that ozone may reduce the immune system's ability to fight off bacterial respiratory infections.



This photo shows a healthy lung airway (left) and an inflamed lung airway (right). Ozone can inflame the lung's lining, and repeated episodes of inflammation may cause permanent changes in the lung.

All these effects are considered to be short-term effects because they eventually cease once the individual is no longer exposed to elevated levels of ozone. However, scientists are concerned that repeated short-term damage from ozone exposure may permanently change the lung. For example, there is concern that repeated ozone impacts on the developing lungs of children may lead to reduced lung function as adults. Also, there is concern that ozone exposure may worsen the decline in lung function that occurs as a natural result of the aging process. Research is underway to help us better understand the possible long-term effects of ozone exposure.

How do scientists know about the health effects of ozone?

EPA has gathered a great deal of information about the health effects of ozone. This information comes from a number of sources, including animal studies, epidemiology studies that compare health statistics and ozone levels within communities, and controlled testing of human volunteers to determine how ozone affects their lung function. In these studies, volunteers are exposed to ozone in specially designed chambers where their responses can be carefully measured. Volunteers are prescreened in medical examinations to determine their health status, and they are never exposed to ozone levels that exceed those found in major cities on a very smoggy day.



Careful testing of human volunteers helps determine how ozone affects the lungs.

Though our understanding of ozone's effects has increased substantially in recent years, many important questions still remain to be investigated. For example: Does repeated short-term exposure to high levels of ozone cause permanent lung damage? Does repeated exposure during childhood to high levels of ozone cause reduced lung function in adults? Scientists are continuing to study these and other questions to gain a better understanding of ozone's health effects.

How can I tell if I am being affected by ozone?

Often, people experience recognizable symptoms as they start to be affected by ozone. These symptoms, described above, include coughing, irritation in the airways, rapid or shallow breathing, discomfort when breathing or general discomfort in the chest, and asthma attacks. When ozone levels are higher than normal, any of these symptoms may be important signals that you should minimize the time you spend outdoors, or at least reduce your activity level, to protect your health until ozone levels decline.

But ozone damage can occur without any noticeable signs. Sometimes there are no symptoms, and sometimes the symptoms are too subtle to notice. People who live in areas where ozone levels are frequently high may find that their initial symptoms of ozone exposure go away over time—particularly when exposure to high ozone levels continues for several days. This does not mean that they have developed resistance to ozone. In fact, scientists have found that ozone continues to cause lung damage even when the symptoms have disappeared. The best way to protect your health is to be proactive in finding out when ozone levels are elevated in your area and taking simple precautions, described below, to minimize your exposure even when you don't experience obvious symptoms.

How can I find out about ozone levels in my area?

EPA and State and local air agencies have been developing a number of tools to provide the public with information on local ozone levels, their potential health effects, and suggested activities for reducing ozone exposure. At the heart of these tools is a nationwide system that monitors ozone levels at key locations. In many areas, information about ozone levels is available on the Internet—usually within several hours after the values are recorded. You can access this information in several forms:

- **Actual air monitoring data.** If you're interested in seeing the actual ozone levels that State agencies have recorded, you can access these data at www.epa.gov/airnow.
- **Ozone map.** This map uses color contours to show ozone concentrations in different parts of the country. The colors on the map change as the ozone concentrations change. The colors are coded to indicate the level of health concern associated with the ozone concentration. For example, green means ozone levels are "good," yellow means they are "moderate," orange means they are "unhealthy for sensitive groups," and red means they are "generally unhealthy." The ozone map is also used in some areas to show a forecast of air quality levels for the next day. Once you understand the color scheme, you can use the map to quickly determine whether ozone concentrations are reaching unhealthy levels in your area. The ozone map appears on some televised weather broadcasts and is also available over the Internet at www.epa.gov/airnow.

- **Pollutant Standards Index.** The Pollutant Standards Index (or PSI—also sometimes referred to as the Air Quality Index) is a standard numerical index EPA has developed for reporting the levels of ozone and other common air pollutants. EPA developed the index to help make it easier for the public to understand the health significance of air pollution levels. Pollutant levels are normally measured in units of parts per million (ppm) or, for particulate matter, in micrograms per cubic meter. To help the public understand the health significance of air pollution concentrations, EPA "translates" the pollutant concentrations to the standard PSI index, which ranges from 0 to 500. A PSI rating of 100 corresponds to the national ambient air quality standard (NAAQS) for the pollutant. This standard is established by EPA under the Clean Air Act to protect public health and the environment.

The higher the PSI rating for a pollutant, the greater the health concern. Though the PSI scale extends to 500, levels above 300 rarely occur in the United States. This booklet and most other references to the PSI do not list health effects and cautionary statements for levels above 300. If ozone levels above 300 should ever occur, *everyone* should avoid exertion outdoors.

The chart below shows ozone concentrations in the left column, the PSI ratings corresponding to these levels in the middle column, and the health implications associated with these ozone levels and PSI ratings in the right column. Note that the ozone ranges given in the left column are generally based on the new 8-hour ozone standard. (EPA revised the standard in 1997 to make it more protective of human health.)

Ozone Concentration (ppm) (8-hour average, unless noted)	Pollutant Standards Index	Air Quality
0.0 to 0.064	0 to 50	Good
0.065 to 0.084	51 to 100	Moderate
0.085 to 0.104	101 to 150	Unhealthy for Sensitive Groups
0.105 to 0.124	151 to 200	Generally Unhealthy
0.125 (8-hr.) to 0.404 (1-hr.)	201 to 300	Very Unhealthy

You may see the PSI for ozone reported in your newspaper or on your local television station. When pollutant levels are high, states are required to report the PSI in metropolitan areas of the U.S. with populations over 200,000.

What can I do to avoid unhealthy exposure to ozone?

You can take a number of steps to protect yourself when ozone concentrations reach unhealthy levels. The chart at the end of this booklet tells you what types of health effects may occur at specific ozone concentrations and what you can do to avoid these effects. If you are a parent, keep in mind that your children are likely to be at higher risk, particularly if they are active outdoors. You may therefore want to pay special attention to the guidance for members of sensitive groups.

In general, when ozone levels are elevated, your chances of being affected by ozone increase the longer you are active outdoors and the more strenuous the activity you engage in. Scientific studies show that:

- At ozone levels above 0.12 ppm, strenuous outdoor exertion for short periods of time (1 to 3 hours) can increase your risk of experiencing respiratory symptoms and reduced lung function.
- At ozone levels between 0.08 and 0.12 ppm, even moderate outdoor exertion for longer periods of time (4 to 8 hours) can increase your risk of experiencing ozone-related effects.

Therefore, EPA recommends limiting outdoor activities as ozone levels rise to unhealthy levels. You can do this by limiting both the amount of time you are active outdoors and your activity level. For example, if you're involved in an activity that requires heavy exertion, such as running or heavy manual labor (see box), you can reduce the time you spend on this activity or substitute another activity that requires less exertion (e.g., go for a light jog rather than a demanding run).

What does exertion have to do with ozone-related health effects?

Most people know that exercise and outdoor activities can play an important role in maintaining good health. Physical exertion helps build up strength in the heart and lungs. What fewer people understand is that exerting yourself outdoors can actually increase your chances of experiencing health effects when ozone concentrations are at unhealthy levels. Why is this true? Think of it this way: Exertion generally causes you to breathe harder and faster. When this happens, more ozone is taken into your lungs, and the ozone penetrates deeper into the parts of the lungs that are more susceptible to injury. Research has shown that respiratory effects are observed at lower ozone concentrations if either the level or duration of exertion is increased. This is why EPA recommends decreasing the level or duration of exertion to avoid ozone health effects.

Examples of typical daily activities that involve moderate exertion include climbing stairs, light jogging, easy cycling, playing tennis or baseball, and stacking firewood. Outdoor occupational activities such as simple construction work, pushing a wheelbarrow with a load, using a sledgehammer, or digging in your garden, would also be considered to involve moderate exertion. Activities that involve heavy exertion include vigorous running or cycling, playing basketball or soccer, chopping wood, and heavy manual labor.



When ozone rises to unhealthy levels, moderate forms of outdoor exercise like walking are safer than strenuous outdoor activities like jogging.

Health Effects and Protective Actions for Specific Ozone Ranges

Ozone Level	Health Effects and Protective Actions
Good	<p>What are the possible health effects?</p> <ul style="list-style-type: none">• No health effects are expected.
Moderate	<p>What are the possible health effects?</p> <ul style="list-style-type: none">• At the lower end of this range (PSI from 51 to 75), few or no health effects are expected.• At the upper end of this range (PSI from 76 to 100), extremely sensitive individuals may experience respiratory effects from prolonged exposure to ozone during moderate exertion outdoors. <p>What can I do to protect my health?</p> <ul style="list-style-type: none">• When ozone levels are at the upper end of the "moderate" range, consider limiting prolonged moderate exertion outdoors if you are extremely sensitive to ozone.

Health Effects and Protective Actions for Specific Ozone Ranges

Unhealthy for Sensitive Groups	<p>What are the possible health effects?</p> <ul style="list-style-type: none">• If you are a member of a sensitive group, ⁽¹⁾ you may experience respiratory symptoms (such as coughing or pain when taking a deep breath) and reductions in lung function, which can cause some breathing discomfort. <p>What can I do to protect my health?</p> <ul style="list-style-type: none">• If you are a member of a sensitive group, ⁽¹⁾ limit prolonged moderate exertion outdoors. In general, you can protect your health by reducing how long and how strenuously you exert yourself outdoors and by planning outdoor activities when ozone levels are lower (usually in the early morning or evening).• You can check with your state air agency to find out about current or predicted ozone levels in your location. This information on ozone levels is available on the Internet at www.epa.gov/airnow.
Generally Unhealthy	<p>What are the possible health effects?</p> <ul style="list-style-type: none">• If you are a member of a sensitive group ⁽¹⁾ you have a higher chance of experiencing respiratory symptoms (such as aggravated cough or pain when taking a deep breath), and reduced lung function, which can cause some breathing difficulty.• Members of the general public may also experience respiratory effects. <p>What can I do to protect my health?</p> <ul style="list-style-type: none">• If you are a member of a sensitive group, ⁽¹⁾ avoid moderate or heavy exertion outdoors. Everyone else—especially children—should limit prolonged moderate exertion outdoors.• Plan outdoor activities when ozone levels are lower (usually in the early morning or evening).• You can check with your state air agency to find out about current or predicted ozone levels in your location. This information on ozone levels is available on the Internet at www.epa.gov/airnow.

Very Unhealthy	<p>What are the possible health effects?</p> <ul style="list-style-type: none"> Members of sensitive groups⁽¹⁾ will likely experience increasingly severe respiratory symptoms and impaired breathing. Many healthy people in the general population engaged in moderate exertion will experience some kind of effect. According to EPA estimates, approximately: <ul style="list-style-type: none"> Half will experience moderately reduced lung function. One-fifth will experience severely reduced lung function. 10 to 15 percent will experience moderate to severe respiratory symptoms (such as aggravated cough and pain when taking a deep breath). People with asthma or other respiratory conditions will be more severely impacted than healthy individuals, leading some to increase medication usage and seek medical attention at an emergency room or clinic. <p>What can I do to protect my health?</p> <ul style="list-style-type: none"> If you are a member of a sensitive group,⁽¹⁾ avoid outdoor activity altogether. Everyone else—especially children—should limit moderate exertion outdoors and avoid heavy exertion altogether. Check with your state air agency to find out about current or predicted ozone levels in your location. This information on ozone levels is available on the Internet at www.epa.gov/airnow.
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1. Members of sensitive groups include children who are active outdoors; adults involved in moderate or strenuous outdoor activities; individuals with respiratory disease, such as asthma; and individuals with unusual susceptibility to ozone.

What can I do to reduce ozone levels?



Motor vehicle emissions are a major contributor to smog. You can help reduce ozone levels by walking, biking, carpooling, or using public transportation as an alternative to driving.

Ground-level ozone is created when certain pollutants, known as "ozone precursors," react in heat and sunlight to form ozone. Cars and other vehicles are the largest source of ozone precursors. Other important sources include industrial facilities, power plants, power mowers, and evaporation of oil-based paints and solvents.

We can all help reduce ozone levels by taking the following steps:

- Drive less. For example, instead of using a car, you may want to walk, use mass transit, or ride a bike.
- Carpool.
- Make sure your car is well-tuned.
- Take care not to spill gasoline when you fill the tank of your car or lawnmower.
- Make sure that you tightly seal the lids of chemical products you use, such as solvents, garden chemicals, or household cleaners.

More ideas about what you can do to help reduce ozone levels in your area can be found on EPA's Website at

<http://www.epa.gov/oar/oaqps/airnow/consumer.html>.